4.

Plankton of the Bermuda Oceanographic Expeditions[1]. I.

G. H. Wailes.

City Museum, Vancouver, B. C.

INTRODUCTION BY WILLIAM BEEBE.

The matter in this series of papers is a continuation of the oceanographic work carried on by myself and my staff of the Department of Tropical Research of the New York Zoological Society, off the island of Nonsuch, Bermuda. Full details of this investigation, together with complete data of hauls, may be found in Zoologica, Volume XIII, Numbers 1, 2 and 3, and Volume XXI, Number 3. I have thought it worth while to add a few paragraphs of the most pertinent data.

Locality.

The area in which the fifteen hundred-odd nets have been drawn is roughly circular and eight miles in diameter. Observations by means of the two light-houses, Gibb's Hill and St. Davids, have made it possible to get accurate sights at the beginning and end of each individual haul. To give the location with more exactness: the eight-mile circle under consideration has its center at 32° 12′ N. Lat. and 64° 36′ W. Long., which point is 160 degrees by the compass, or south-south-east of Nonsuch. Its horizontal boundaries are as follows:

Northern rim:	32° 16′ N. Lat.
Southern rim:	32° 8′ N. Lat.
Eastern rim:	64° 31′ 20″ W. Long.
Western rim:	64° 40′ 40″ W. Long.

At no place is its bottom less than 1,000 fathoms in depth. It slopes rather rapidly in the northeastern corner to 1,357 fathoms, and along its southern border is between 1,400 and 1,500 fathoms deep. My first deep dive in the bathysphere, of 803 feet, was in the southwest sector, and the later ones of 1,426, 2,200, 2,510 and 3,028 feet were all near the northern rim.

Methods.

The deep-sea trawling has all been done from the aft deck of the tug *Gladisfen*. When the rim of the imaginary cylinder has been reached the weight at the end of the wire is put overboard and the cable gradually paid out at a 30° angle. Six nets are usually attached, 1-metre nets of standard oceanographic design, 20 feet in length, with the posterior portion of No. 2

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bolting silk and the upper part of No. 0 bolting silk. In addition to this there is the usual collar of shrimp netting, with 10 mm. mesh.

These nets are placed along the cable at measured intervals so that at a 30° angle they will haul 100 fathoms apart, usually from the surface to 500 fathoms, or from 500 to a depth of 1,000 fathoms. After as long a haul as the time will permit the nets are pulled in and the contents taken ashore to the laboratory for sorting and study.

The exact depth at which the nets are drawn is assured by the use of a special bathygraph pressure gauge which registers the entire course of the lowest net from surface to greatest depth and back to surface again, together with the duration of the haul.

All of the deep-sea hauls are made with horizontal tow nets unprovided with closing apparatus. After the first few hauls were made off Bermuda at deep levels, it was found advisable, owing to the relatively small amount of captured animal life, to extend the length of towing time for the nets up to periods of four to six hours. Experience on the *Arcturus* and other expeditions had taught us that closing mechanisms operating at great depths were uncertain pieces of machinery at best, and quite useless for gathering an adequate representation of the abyssal fauna. The necessity of long horizontal hauls has completely precluded their use.

Two phases of the Bermuda Oceanographic Expedition hauls, seldom if ever duplicated by other expeditions, are exceptionally interesting. The first of these is the accomplishment of hundreds of hauls at various levels in one location and over long periods of time, and the second is the long duration of each individual haul at its level compared with the time spent in going up and down. These two conditions make it relatively easy, with experience, to determine the life zones in the sea to which each organism belongs.

Complete time records of all of the nets used during the Bermuda Oceanographic Expeditions have been kept, and the following data show the percentage of time spent by a net at the desired depth compared with the total time the net was in the water:

100-*fathom nets*: These nets towed at this depth from 86% to 96% of their total towing time, their average effectiveness being 91.4%.

500-*fathom nets*: The nets towed at this depth from 70% to 83% of their total towing time, their average effectiveness being 79.4%.

1,000-*fathom nets*: The nets towed at this depth from 59% to 72% of their total towing time, their average effectiveness being 64.4%.

The exact determinations of the life zones of animals of the Bermuda deep-sea fauna, have been restricted, so far, to fishes. These are now being studied in the cases of the larger invertebrates and plankton.

Contents of a Typical Net Haul.

Net 779, Michael Sars metre net; Vessel, Tug *Gladisfen;* Date, July 5, 1930; Location, 5 m. SE to 15 m. SExS¾S of Nonsuch Island, Bermuda; Weather, overcast in A.M., rain squalls, clearing in P.M.; Wind, SW, 2 to 3; Sea, considerable swell, diminishing in P.M.; Time, beginning of haul 9:04 A.M., ending of haul 2:25 P.M., duration of haul, 5 hours, 21 minutes; Depth of net, 800 fathoms; Length of cable, 2,925 metres; Angle of cable, 30°.

Contents of Net.

General Character: Mostly copepods, schizopods and sagitta.
Copepods, comprising a dozen or more species, mostly calanoids, with also *Corycaeus, Oithona,* etc.
Schizopods, chiefly small species of *Euphausia,* with a dozen others belonging to two or three genera.

Shrimps, one specimen near *Pandalus danae.*
Ostracods, a few of one or two species.
Amphipods, few and small, a dozen individuals of four or five species.
Sagitta, apparently two or three species.
Polychaetes, one *Tomopteris septentrionale.*
Siphonophores, *Diphys truncata.*
Sponges, fair number of spicules of various kinds.
Radiolaria, large numbers of portions of a hexagonal framework and a few small, conical specimens mostly incomplete; numbers of perforated spherical species and Astrophaeroidea.
Diatoms, almost entirely absent. One specimen of *Asteromphalus heptactis,* also one cell of *Melosira moniliformis* and a *Coscinodiscus.*
Tintinnoinea, one *Tintinnopsis cylindrica* and one *Parafavella* near *P. acuta.*
Foraminifera, few, comprising two or three species.
Dinoflagellates, absent.
Fish larvae, three present, one belonging to a deep-sea species, with very large lower jaw and black spots on sides.

Fish, adolescent and adult:

6 *Lampanyctus warmingi,* 11 to 21 mm.
3 *Myctophum benoiti,* 11, 12 mm.
1 *Lampadena chavesi.*
13 *Myctophum laternatum,* 12 mm.
14 *Cyclothone signata.*
117 *Cyclothone microdon.*
1 *Cyclothone pallida.*
1 *Bregmaceros macclellandii,* 45 mm.
2 *Omosudis lowi,* 11, 38 mm.
1 *Stomias ferox,* 80 mm.
1 *Lestidium intermedium,* 87 mm.

In the preliminary work of this report, represented by ZOOLOGICA, Volumes XXI, Number 4 to 8 inclusive, the labors of Mr. G. H. Wailes have been very great, for he has patiently sorted out the various elements of many typical plankton hauls made in the course of these expeditions, and thus rendered the various phyla available for study by specialists.

This has resulted in a real contribution to the distribution and relative abundance of marine life in the vicinity of Bermuda, but it is only a beginning, for of the fifteen hundred-odd hauls made, from 1929 to the present time, selections for the following reports have been made from only 44, or about 3%.

Samples of marine plankton collected by Dr. William Beebe off Bermuda have been submitted to me and form the subject of the present reports. Further reports will be issued as the material is identified and reported upon.

I wish to express my thanks to Dr. Beebe for the privilege of examining the material and to all those who have kindly identified specimens, among whom I would especially mention the following for their courtesy in identifying specimens in the groups on which they are acknowledged authorities: Mrs. Edith Berkeley and Mr. C. C. A. Monro (Polychaetes), Dr. McLean Fraser (Hydroids), Mr. Clarence R. Shoemaker (Amphipods), Dr. C. B. Wilson (Copepods) and Dr. W. M. Tattersall (Schizopods), also Dr. W. A. Clemens for library facilities at the Departure Bay Station of the Biological Board of Canada.

Locality.

The samples numbered from 1 to 13 were obtained in 1930 from an area eight miles in diameter, situated about eight miles south of Nonsuch Island, the center of this area being in 32° 12′ N. Lat. and 64° 36′ W. Long.

Samples numbered from 14 to 24 were taken during the autumn of 1933 somewhat farther inshore.

Table I.

Data on hauls.

Sample No.	Net No.	Depth Fath.	Depth Metres	Date 1930	Time of Haul	Duration of Haul	Type of Net
1	779	800	1463	5 July	9.04 A.M.	5 hrs. 21 min.	1 metre
2	870	100	183	11 Sept.	10.03 A.M.	2-27	" "
	876	100	183	12 Sept.	11.22 A.M.	3-00	" "
3	871	200	366	11 Sept.	10.03 A.M.	2-27	" "
	877	200	366	12 Sept.	11.22 A.M.	3-00	" "
4	872	300	549	11 Sept.	10.03 A.M.	2-27	" "
	878	300	549	12 Sept.	11.22 A.M.	3-00	" "
5	873	400	732	11 Sept.	10.03 A.M.	2-27	" "
	879	400	732	12 Sept.	11.22 A.M.	3-00	" "
6	874	500	914	11 Sept.	10.03 A.M.	2-27	" "
	880	500	914	12 Sept.	11.22 A.M.	3-00	" "
7	875	600	1097	11 Sept.	10.03 A.M.	2-27	" "
	881	600	1097	12 Sept.	11.22 A.M.	3-00	" "
8	891	700	1280	15 Sept.	9.20 A.M.	4-00	" "
	896	700	1280	16 Sept.	9.29 A.M.	4-26	" "
	902	700	1280	17 Sept.	9.10 A.M.	4-05	" "
9	892	800	1463	15 Sept.	9.20 A.M.	4-00	" "
	897	800	1463	16 Sept.	9.29 A.M.	4-26	" "
	903	800	1463	17 Sept.	9.10 A.M.	4-00	" "
10	868	900	1646	10 Sept.	9.38 A.M.	2-52	" "
	886	900	1646	13 Sept.	9.33 A.M.	4-27	" "
	887	900	1646	13 Sept.	9.33 A.M.	4-27	" "
11	858	1000	1829	6 Sept.	9.07 A.M.	4-23	" "
	864	1000	1829	8 Sept.	9.29 A.M.	4-01	" "
	869	1000	1829	10 Sept.	9.38 A.M.	2-52	" "
12	900	0	0	16 Sept.	8.00 A.M.	1-00	" "
13	976	0	0	12 Oct.	2.00 A.M.	2-00	" "
				Surface Hauls 1933			
14	1358	0	0	17 Sept.	7.35 P.M.	1-00	1 ft. Diatom
15	1370	0	0	24 Sept.	5.00 A.M.	0-30	½-Metre
16	1378	0	0	27 Sept.	4.45 A.M.	0-20	1 Metre
17	1382	0	0	27 Sept.	4.45 A.M.	0-20	1 Metre
18	1380	0	0	27 Sept.	5.25 A.M.	0-20	1 Metre
	1381	0	0	27 Sept.	5.45 A.M.	0-20	1 Metre
19	1408	0	0	11 Oct.	7.45 P.M.	0-20	1 Metre
20	1411	0	0	11 Oct.	7.45 P.M.	0-20	½-Metre Diatom
21	1439	0	0	28 Oct.	2.15 P.M.	0-20	1 Metre
	1441	0	0	28 Oct.	2.40 P.M.	0-20	1 Metre
	1443	0	0	28 Oct.	3.15 P.M.	0-15	1 Metre
22	1442	1.6	3	28 Oct.	2.40 P.M.	0-20	1 ft. Diatom
	1444	1.6	3	28 Oct.	3.15 P.M.	0-15	1 ft. Diatom
23	1446	0	0	2 Nov.	4.45 A.M.	1-15	1 Metre
	1448	0	0	2 Nov.	6.00 A.M.	1-15	1 Metre
	1449	0	0	2 Nov.	4.45 A.M.	1-15	½-Metre
	1450	0	0	2 Nov.	6.00 A.M.	1-15	½-Metre
24	1457	1.6	3	11 Nov.	3.35 P.M.	0-20	½-Metre

From Table I it will be seen that each sample represents the combined results of from one to four separate net hauls, a total of 44 hauls being included out of more than fifteen hundred made by Dr. Beebe up to the present time.

General Composition of the Plankton.

Previous to the samples being received, in fact on the day of their collection, the larger organisms such as fish, large crustaceans and medusae, had been removed. The following remarks apply, therefore, to the remainder.

Deep-water Hauls: These, comprising Samples 1 to 11, were large, each consisting of from 400 to 500 cubic centimetres of organisms. All had mixed with them considerable quantities of long hairs and gelatinous material of unrecognized origin, much entangled with chaetognaths and crustaceans.

All the samples were of a similar general character and consisted of approximately 80% Crustacea, 10% Chaetognatha, 5% Coelenterata and 5% of various other organisms and débris.

The crustacean portions were composed on an average of about (by bulk) 40% schizopods, 35% shrimps and larvae, and 20-25% copepods, with a small mixture of amphipods, ostracods, isopods, crab zoea and other decapod larvae amounting to 1% or 2%.

Shallow-water Hauls: These were small in amount, varying from about 5 to 20 cubic centimetres each. The surface tows (Samples 12 and 13, Nets 900 and 976) were also small as they consisted only of portions of the hauls.

The surface hauls as represented by Samples 14 to 24 show great variation in the relative proportions of the various groups composing them, as can be seen from Table II.

Table II.

Estimated percentages (by bulk) of the organisms comprising samples 14 to 24. (Those present but not equal to 1% are indicated by "x").

Time	Pre-daylight Hauls, 4:45 to 6:00 A.M.						Daylight Hauls, 2:15 to 3:35 P.M.			Post-daylight Hauls, 7 to 8:00 P.M.	
Sample No.	15	16	17	18	19	23	21	22	24	14	20
Copepoda	87	25	38	5	25	82	2	3	25	15	22
Shrimps and Larvae	10	72	50	60	37	10	92	96	68	70	2
Crab Zoea	2	2	10	2	2	1	2	1	2	x	1
Squilla Larvae	—	—	—	x	—	—	1	—	1	—	—
Amphipoda	—	x	1	30	1	1	—	—	—	x	—
Isopoda	1	—	—	1	x	1	—	—	—	—	—
Ostracoda	x	x	x	x	x	x	x	x	x	x	x
Polychaeta	x	—	—	—	x	—	x	—	—	10	—
Chaetognatha	x	—	1	2	30	1	—	—	2	5	70
Siphonophora	—	—	—	—	3	3	1	—	1	—	5
Medusae	—	—	x	—	1	1	x	x	—	—	x
Tintinnoinea	x	x	—	—	—	—	—	—	—	x	—
Debris, etc.	—	1	—	—	1	x	2	—	1	—	x

These differences occur even in the case of hauls taken simultaneously, as were Nos. 16 and 17, and are still more accentuated in No. 18 which was taken immediately afterward. This latter sample was the only one in which amphipods were present in larger quantities than 1%. In this instance the species *Synopia ultramarina* formed 30% of the catch.

General Results.

Nearly all of the identifications are new records for this region and extend the known distributions more or less considerably.

Aside from the pelagic organisms which are generally distributed in the oceans, the collection consists largely of species previously recorded from the tropical and eastern Atlantic and the Mediterranean areas.

An unexpected result of the examination of the material was the almost complete absence of diatoms and dinoflagellates. This may be due to Bermuda being situated in the Sargasso sea area where certain types of plankton are less plentiful than elsewhere.

5.

Plankton of the Bermuda Oceanographic Expeditions. II. Notes on Protozoa[1].

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(Plates I & II).

This is one of a number of papers dealing with the planktonic contents of a selected series of nets drawn at various levels off the coast of Bermuda on the Bermuda Oceanographic Expeditions of the New York Zoological Society under the direction of Dr. William Beebe. Full details of the nets, locality, etc., will be found in Zoologica, Volume XIII, Numbers 1, 2 and 3, and Volume XXI, Numbers 3 and 4.

The following 39 species of Protozoa were taken in these nets:

PHYLUM PROTOZOA.

Subphylum Mastigophora.

Class Phytomastigoda.

Order Chrysomanadida.

Family Silicoflagellidae.

Dictyocha fibula (Ehrenberg). Rare.

Order Dinoflagellida. (Dinoflagellates).

Suborder Diniferina.

Family Noctilucidae.

Noctiluca scintillans (McCartney). Rare.

Family Peridinidae.

Goniodoma polyhedricum (Pouchet).
Gonyaulax digitale (Pouchet).
Peridiniopsis asymmetrica Mangin.
Peridinium cerasus Paulsen.
Peridinium claudicans Paulsen.
Peridinium conicum (Gran).
Peridinium grani Ostenfeld.
Peridinium oblongum (Aurivillius).
Ceratium fusus (Ehrenberg).
Ceratium trichocerus (Ehrenberg).
Ceratium tripos var. *atlantica* Ostenfeld.
Ceratium karsteni Pavillard.

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Suborder Adinina.

Family Prorocentridae.

Prorocentrum micans Ehrenberg.

The dinoflagellates live in the upper layers of the ocean; most of the species recorded above were captured in surface hauls (Nets 1471, 1472, 1475 and 1476). They are all generally distributed in the North Atlantic ocean, none being purely tropical species.

Subphylum Sarcodina.

Class Actinopoda.

Subclass Radiolaria.

The Radiolaria occurred very sparsely in the deep-water hauls and the majority of individuals were mutilated or fragmentary. Probably nearly twenty species are represented. The material awaits further study.

Subphylum Infusoria.

Class Ciliata.

Order Heterotricha.

Suborder Tintinnoinea.

Examination of Haul 779 made in 800 fathoms and upward, 8 miles south of Bermuda, on July 5, 1930, afforded the following list of 22 species, of Tintinnids, except *Tintinnopsis bermudensis*.

No species occurred numerously and all (except *Parundella major*) have been recorded previously from either the tropical Atlantic, including the Sargasso sea, North Atlantic or Mediterranean sea.

Parundella major was first described in 1925 from the Strait of Georgia, British Columbia, and has also been recorded off San Francisco.

Tintinnopsis bermudensis occurred fairly numerously and was the only species observed in Surface Hauls 1355 and 1370 taken on Sept. 17 and 24, 1933 (close to the shore of Bermuda over depths of five fathoms or less). In 16 similar hauls taken from Sept. 27 to Nov. 11, 1933, no species of tintinnid was seen.

In the accompanying plates figures are given of the species as here recorded.

An examination of 24 hauls made during September, 1930, at depths from 100 fathoms to 1,000 fathoms, 8 miles off Bermuda, disclosed no tintinnids as present. Neither were any present in two surface hauls made at the same time and place.

For information on the synonymy and distribution of the species, the conspectus of this suborder by Kofoid and Campbell (University of California Press, Vol. 34, pp. 1-403, 697 Figs. in text, 1929) should be consulted.

Family Codonellidae Kofoid and Campbell.

Tintinnopsis Stein emended.

T. bermudensis Brandt. (Fig. 1).

T. cylindrica Daday. (Fig. 2). Generally distributed.

T. major Meunier. North Atlantic.

Codonella Haeckel emended.

C. amphorella Biedermann. (Fig. 5).

C. angusta Kofoid and Campbell. Sargasso sea.

C. apicata Kofoid and Campbell (Fig. 4).

C. nationalis Brandt. (Fig. 7). Atlantic ocean.

C. oceanica Brandt emended. (Fig. 8). Gulf Stream.
C. rapa Kofoid and Campbell. (Fig. 6).
C. recta Kofoid and Campbell. Agulhas Current.

Family Codonellopsidae Kofoid and Campbell.
Stenosemella Jörgensen.
S. ventricosa (Claparède and Lachmann). (Fig. 3).
Codonellopsis Jörgensen.
C. longa Kofoid and Campbell. (Fig. 17).
C. tessellata (Brandt). (Fig. 16). Sargasso sea.

Family Cyttarocylidae Kofoid and Campbell.
Cyttarocylis Fol emended.
C. magna Brandt. (Fig. 15).
C. plagiostoma (Daday). (Fig. 18). Atlantic ocean.

Family Ptychocylidae Kofoid and Campbell.
Epiplocylis Jörgensen.
E. sargassensis (Brandt) emended. (Fig. 9).

Family Xystonellidae Kofoid and Campbell.
Parundella Jörgensen emended.
P. major Wailes. (Fig. 20). Off west coast of North America.

Family Undellidae Kofoid and Campbell.
Proplectella Kofoid and Campbell.
P. acuta Jörgensen. (Fig. 11). Mediterranean sea.
P. claparèdei (Entz Sr.). (Fig. 10).

Family Dictyocystidae Haeckel emended.
Dictyocysta Ehrenberg emended.
D. dilatata Brandt. (Figs. 12, 13). Sargasso sea.
D. lata Kofoid and Campbell. (Fig. 14). Sargasso sea.

Family Tintinnidae Claparède and Lachmann emended.
Tintinnus Schrank emended.
T. macilentus Jörgensen emended. (Fig. 19). North Atlantic, New Zealand.

Order Peritrichida.
Family Vorticellidae.
Cothurnia imberbis Ehrenberg.

Class Suctoria.
Family Acinetidae.
Acineta tuberosa Ehrenberg

The last two species were attached to floating alga. They are littoral forms and generally distributed.

EXPLANATION OF THE PLATES.

Note: All Figures magnified 375 times.

Plate I.

Fig. 1. *Tintinnopsis bermudensis* Brandt. Total length 84-94μ, greatest diameter 60-68μ, diameter of collar 45μ.

Fig. 2. *Tintinnopsis cylindrica* Daday. Diameter 38-40μ, length 140-150μ.

Fig. 3. *Stenosemella ventricosa* (Claparède & Lachmann). Length 68-83μ, diameter 55-68μ.

Fig. 4. *Codonella apicata* Kofoid & Campbell. Length 75μ, greatest diameter 59μ, diameter of collar 42μ, height of collar 16μ.

Fig. 5. *Codonella amphorella* Biedermann. Length 89-98μ, greatest diameter 55μ, length of horn, 18-26μ, length of collar 22-23μ, diameter of neck 36-40μ.

Fig. 6. *Codonella rapa* Kofoid & Campbell. Length 90-96μ, greatest diameter 49-50μ, length of horn 20μ, length of collar 23μ.

Fig. 7. *Codonella nationalis* Brandt. Length 74-84μ, greatest diameter 55-64μ, length of collar 19-20μ.

Fig. 8. *Codonella oceanica* Brandt emended. Length 84μ, greatest diameter 66μ.

Fig. 9. *Epiplocylis sargassensis* Brandt emended. Length 132μ, greatest diameter 70μ.

Fig. 10. *Proplectella claparèdei* (Entz Sr.). Length 58-65μ, greatest diameter 40-42μ, aperture 36μ.

Fig. 11. *Proplectella acuta* Jörgensen. Length 68μ, diameter 39μ, aperture 33μ.

Figs. 12, 13. *Dictyocysta dilatata* Brandt. Length 61-65μ, diameter 40-45μ, diameter of collar 34-39μ, height of collar 16μ.

Fig. 14. *Dictyocysta lata* Kofoid & Campbell. Length 65μ, diameter of bowl 53μ, diameter of collar 50μ, height of collar 30μ.

Plate II.

Fig. 15. *Cyttarocylis magna* Brandt. Length 268μ, greatest diameter 130μ.

Fig. 16. *Codonellopsis tessalata* (Brandt). Length of bowl and neck 80μ, diameter of bowl 68-70μ, diameter of neck 42-52μ, length of horn 32-42μ, total length up to about 225μ.

Fig. 17. *Codonellopsis longa* Kofoid & Campbell. Total length 235μ, greatest diameter of bowl 65μ.

Fig. 18. *Cyttarocylis plagiostoma* (Daday). Length 106-123μ, diameter of aperture 105-117μ.

Fig. 19. *Tintinnus macilentus* Jörgensen emended. Length 160μ, oral aperture 38μ diameter, aboral aperture 24μ diameter.

Fig. 20. *Parundella major* Wailes. Diameter 30-32μ, length 130-136μ.